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*THE MATHEMATICS OF NAVAL STRATEGY AND TACTICS.**Manuel Pratique de Cinématique navale et maritime.*

By Captain Leon Vidal. Pp. viii+171. (Paris: Gauthier-Villars, 1905.) Price 7.50 francs.

THIS book was undertaken by the author in accordance with instructions from the Minister of Marine issued seven years ago. Captain Vidal was directed to collect in a single volume the numerous essays on mathematical naval tactics contributed by various authors, French and foreign, and scattered over many publications. Officers of the French Navy were asked officially to give all possible assistance to the compiler, and many of them have done so. The laborious task has been admirably performed, various problems dealt with have been classified, and those relating to similar subjects have been grouped in distinct chapters. Captain Vidal has drawn largely upon work done by other officers, and acknowledges the fact. He is an enthusiast on the subject and has supplemented theorems due to others by much original work, extending or completing his scheme. Solutions alone are given and detailed demonstrations are avoided, so that the volume is compressed within narrow limits in proportion to the range and variety of subjects dealt with. In order to facilitate the practical use of his book by naval officers, elaborate numerical tables have been calculated by which readers can construct diagrams representing particular cases that may require to be dealt with either during naval manoeuvres or in warlike operations. Numerous illustrations are introduced, and the descriptions are brief and clear throughout. Captain Vidal had to examine and collate an enormous mass of material produced during the last thirty years, and it is not surprising, therefore, that he has been so long engaged on the book. French naval officers and professors have done most in this field, but foreign authorities have also been laid under contribution, and the volume will probably long remain the chief book of reference on its special subject.

The science of naval cinematics, says the author, "consists in the study of the movements of vessels considered ordinarily as moving points, but in many instances it also takes account of their length and gyration, as well as their powers." For the most part, in the strategical theorems dealt with it has been assumed that ships may be treated as particles, the influence of length and turning-power being neglected. Further, it is generally assumed that movements take place in a calm and tideless sea. Certain corrections are suggested subsequently in order to make allowance for wind, wave, and current, but these sections are very brief, besides being incomplete in treatment, as is indeed unavoidable from the nature of the case. The turning-powers of steamships are but lightly touched, although they are most important in tactical manoeuvres either for single ships or squadrons.

NO. 1868, VOL. 72]

It is well known that the mathematical training of French naval officers is more extensive than that given to officers in the Royal Navy, and Captain Vidal is exceptionally well equipped in this respect, even among French officers. The book is indeed mainly a collection of geometrical theorems, in two dimensions, bearing upon the movements of ships or squadrons performed under certain assumed conditions. Many of these theorems can have little practical value, but not a few have been made the basis of modern French naval manoeuvres. The fundamental idea is that when the course of a ship departs from a straight line it may be assumed to follow a logarithmic spiral. Captain Vidal enumerates the principal properties of that curve, and gives tables for estimating the lengths of arcs and chords, the values of tangents at different points, and other useful items. He takes special cases for spirals described about a fixed point, or about a point in the rectilinear course of another moving body, so as to examine the relative positions, from instant to instant, of two vessels or two squadrons. Theorems attaching to the well-known "curves of search" employed by ships when scouting, or endeavouring to detect the position of an enemy who attempts either to arrive at or depart from some fixed point, are discussed at length. In another chapter theorems dealing with the movements of two vessels such as may take place in single-ship actions are grouped and discussed fully. In a third chapter the most effective methods of concentration for scattered ships belonging to a fleet sent out for purposes of observation and scouting are dealt with. In another section the "lines of observation" to be patrolled by ships of a fleet, and the organisation required in order that an enemy cannot pass through the line without detection, are discussed. The influences of currents in rivers on the movements of vessels and the effect of wind and sea are also briefly investigated.

Captain Vidal writes fully as much as a mathematician as a naval officer. In his opinion the study of mathematics is both necessary and beneficial to all naval officers, whose duty he considers it to be to lay down conditions for programmes of ship-construction. Consequently, he urges that officers should understand the work of the engineer and the trend of industrial progress if they are to give good advice and be the *corps directeur* of a modern fleet. Naval officers must, in his opinion, "make, in war, the synthesis of actual forces and guide them in producing the desired effects." To ensure success in this high mission the study of naval cinematics is essential, in Captain Vidal's judgment, since every advance in that science "enables one to foresee more clearly the results of movements of ships and to employ new combinations with intelligence." There is much force in this contention, but the class of work dealt with by Captain Vidal could be undertaken only by the *élite* of officers in the Royal Navy. His treatment would be over the heads of average naval men, and it is not likely to assist them in their daily work. The fact that the standard of mathematical attainment by average officers in our naval service is not so high

as in the French Navy may reduce the number of English readers of the book. But, happily, we possess many naval officers fully competent to take their place in scientific discussions of naval strategy and tactics. They will find much that is suggestive in Captain Vidal's book, and may be trusted to appreciate its investigations properly as well as to deduce therefrom rules for guidance, which will assist brother officers not so well instructed as themselves in the practical application of the theorems which Captain Vidal has collected. Shortly stated, the volume is better suited for the student than for the average naval officer, but it deserves a place in the professional libraries of all modern fleets.

W. H. WHITE.

#### THE CORRESPONDENCE OF HUYGENS.

*Œuvres complètes de Christiaan Huygens.* Publiées par la Société Hollandaise des Sciences. Tome dixième. Correspondance 1691-1695. Pp. 816. (Nijhoff: La Haye, 1905.)

THIS volume completes the publication of the scientific and miscellaneous letters of Huygens, the ten volumes comprising in all twenty-nine hundred letters and memoranda. There is, perhaps, not so much variety in the contents of the present volume as in those of previous ones, and the great majority of the letters of interest written during the last five years of Huygens's life have been published before, but they have now in many cases been further illustrated by the addition of rough notes from the books of *adversaria* of the author.

The correspondence with Leibnitz, which had been resumed in 1688 after a long interruption, went on regularly during the years 1691-5, dealing partly with pure mathematics, partly with the theory of universal gravitation. It shows that Huygens never became reconciled to the use of the differential calculus, but continued to prefer geometrical methods. In 1691 he acknowledges the utility of the calculus, and says that he has made some progress in it; yet in the very last letter to Leibnitz (of December 27, 1694) Huygens remarks that the new method "ne me demeure pas présente à l'esprit quand j'ai discontinué longtemps à m'y exercer." But the numerous letters and notes on the quadrature of curves, especially of the folium of Descartes, exchanged between Marquis de l'Hospital and Huygens show that the latter's power of dealing with geometrical problems was as vigorous as ever. He also continued to correspond with Fatio de Duillier, whose letters foreshadow the accusation of plagiarism which he launched against Leibnitz in 1699, as he from 1691 repeatedly assured Huygens that Newton was the discoverer of the differential calculus, and that it would not be pleasant for Leibnitz if Newton's letters to him were published. Huygens, who continued to think the new calculus unnecessary, did not omit to tell Leibnitz that, according to Fatio, Newton knew more of the inverse problem of tangents than Fatio and Leibnitz did; to which Leibnitz quietly replied that everybody had his own ways of proceeding, and perhaps he

knew of some which Newton had not yet perceived. Fatio several times mentioned in his letters that he intended to publish a new edition of the "Principia," as Newton had declined to do it himself, and proposed to expand it into a folio volume, which he flattered himself would be more easily understood than Newton's quarto.

With Leibnitz, Huygens also exchanged ideas about the nature and cause of gravitation. In 1692 Leibnitz remarked that a vortex like that assumed by Descartes is necessary to explain why the earth's axis remains parallel to itself, while the fact that all planets and satellites move in the same direction also points to their being carried along by some fluid matter. He rejects the idea of Cassini, that the orbit of a planet is not an ellipse, but a Cassinian oval, since no physical reason had been given for this hypothesis. The spherical shape of a drop of water, the fall of a body to the earth, and the motion of the planets are all, according to Leibnitz, caused by the "materia ambiens." Huygens, on the other hand, thinks that the sphericity of a drop is more likely caused by the rapid motion of some matter which circulates inside, and as to the planets he fails to see why we should assume the existence of vortices when Newton had proved that the law of inverse squares "with the centrifugal force" produces the ellipses of Kepler. He also makes other objections to the theory of Descartes, particularly to the small spheres of the second element which revolve round the accumulated first element (the sun), and are supposed to have been formed by the corners of the original matter being rubbed off; for if this matter offered any resistance to this rubbing, what should limit the resistance, and if there were none, what should prevent the total destruction of the particles? The vortex which should preserve the parallelism of the earth's axis is incompatible with the motion of the same matter in all directions which should produce gravitation; an objection to which Leibnitz could only reply that we have two such independent circulations here on the earth, causing gravity and magnetism. Huygens acknowledges that vortices are a convenient means of explaining the common direction of planetary motions, but the constant eccentricity of a planet and the variable velocity in the orbit cannot be accounted for by the theory.

In this connection it is most interesting to read some notes written by Huygens to the well known "Vie de Monsieur Descartes," published anonymously by A. Baillet in 1691. According to Huygens, Descartes was very successful in getting his conjectures and fictions accepted as truth, just as novels may be taken for real history; but, on the other hand, he dealt with tangible things, and not with mere words as earlier philosophers had done. Bacon did not understand mathematics and was wanting in penetration as regards physics, being unable even to conceive the possibility of the earth's motion, which he mocked as an absurdity. Galileo had enough of mental power and mathematical knowledge to make progress in physical science, and he was the first to make discoveries as to the nature of motion, although